ARTERIAL CATHETERIZATION WITH ULTRASOUND: IDENTIFYING BARRIERS FOR COMPLIANCE WITH A LOCAL ARTERIAL LINE POLICY

by

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As members of the DNP Project Committee, we certify that we have read the DNP project prepared by *Jal A. Atkielski*, titled *Arterial Catheterization with Ultrasound: Identifying Barriers for Compliance with a Local Arterial Line Policy* and recommend that it be accepted as fulfilling the DNP project requirement for the Degree of Doctor of Nursing Practice.

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TABLE OF CONTENTS

TABLE OF CONTENTS – *Continued*

LIST OF FIGURES

LIST OF TABLES

ABSTRACT

Studies demonstrate that with the innovation of ultrasonography, the visualization via two-dimensional imaging increases first-attempt success rates with arterial catheterization. In contrast, multiple attempts from the traditional landmark method result with an increased risk of hematoma and arterial spasms (Anantasit, Cheeptinnakorntaworn, Khositseth, Lertbunrian, & Chantra, 2017). A local facility in Tucson, Arizona has a current policy in affect that requires the use of ultrasound with radial/brachial arterial catheterization. Observation conducted by the principal investigator revealed several arterial catheterizations attempts without the use of ultrasonography. This project identified barriers as to why certified registered nurse anesthetists (CRNAs) are noncompliant with the policy, which requires the use of ultrasonography (US) during arterial catheterization. A survey was created using the online tool, *Survey Monkey*, which posed 10 questions to CRNAs pertaining to years of experience, current policy requirements, utilization of US, and why or why not the use of US with arterial catheterization.

Correspondence approved by the institutional review board (IRB), was sent to a convenient sample of 25 CRNAs who work within the operating room at the local facility and explained the aim of the project and the importance of participant anonymity. The correspondence was added to the *Survey Monkey* tool and distributed. A goal of 30% participation was set for meaningful analysis; 52% of which was achieved. The responses to each of the 10 questions were analyzed via the "analyze results" function tab within the *Survey Monkey* tool. Non-open-ended responses were aggregated and placed into data trend graph for interpretation. The survey demonstrated that 54% of CRNAs are unaware that a policy exists for use of US with arterial catheterization. Additionally, 46% of CRNAs are aware of an existing

policy that requires the use of US, however they are reluctant to follow it. A third barrier was identified that 31% of respondents suggested that US was unavailable for use.

Keywords: Ultrasonography, ultrasound guidance, Seldinger technique, arterial cannulation, catheterization, vasospasm, certified registered nurse anesthetist, Allen's test, *Survey Monkey*, and *Word Cloud.*

INTRODUCTION

Background Knowledge

Routinely, patients admitted to the intensive care unit as well as those with unstable vital signs during surgery, may require invasive arterial catheters for continual blood pressure assessment as opposed to noninvasive blood pressure monitoring. Certified registered nurse anesthetists (CRNAs) can place arterial catheters that reside within the artery to provide consistent blood pressure monitoring for steadfast titration of supportive medications (Tegtmeyer, Brady, Lai, Hodo, & Braner, 2006). The Seldinger technique is used in either two fashions; over-the-needle or over-the-wire fashion. In both cases, the artery is palpated proximal to needle insertion and the needle penetrates the skin and enters the vessel. Depending on each approach, once the needle is within the artery by evidence of a pulsatile flash, either the catheter is introduced directly or a wire is advanced into the vessel for the catheter to follow. When accessing arterial vessels with traditional palpation and Seldinger technique, patient anatomy, age, disease process, dehydration, hypovolemia, body mass index, and situation can act as barriers for successful cannulation (Tegtmeyer et al., 2006). One barrier may exist in narrowing of the vessels, therefore making it more difficult to locate. Another obstacle may cause vessels to lose structural integrity. Thus, once the needle enters the vessel, hematoma or vasospasm may result in a loss of palpation of the vessel. For these reasons, multiple puncture attempts are often required, which can further lead to infection, hematoma, and vasospasm. In a multicenter randomized controlled trial by Seto et al. (2015), vasospasm is defined and identified by the operator, when resistance or patient discomfort is observed during catheterization. The study revealed those patients who experienced vasospasm endured multiple puncture attempts (Seto et

al., 2015). Moreover, if vasospasm results, the CRNA must abandon the attempted puncture site and attempt a different location regardless of the technique (Tegtmeyer et al., 2006). Not only does this practice cause delays, it also may contribute to an increase of utilization of resources. Saving of resources begins to accrue because of reduced need to treat complications. By reducing average attempts for insertion, incidence of insertion failures, and by reducing the incidence of complications, economic savings are expected (Calvert et al., 2004). Ultrasonography (US) is an innovative technology that is readily available to CRNAs. However, the implementation of ultrasound to guide arterial cannulation is uncommon, thus leading to increased risks for complications (Tegtmeyer et al., 2006). US provides the CRNA with direct visualization of the artery rather than blindly puncturing a pulsatile pulse for insertion of the needle. The use of US on all arterial line placements should be evaluated as it is an innovation that is under-used in the operating room. Moreover, US provides a significant cost savings benefit, which not only reduces waste from failed insertion attempts, but more importantly, the added cost from resources to treat complications from failed attempts (Calvert et al., 2004). On the other hand, the utilization of US within certain facilities provide a bill-for-service with arterial catheterization. However, this point is beyond the scope of this project and should be considered for further analysis.

Purpose

This project was designed to address barriers for compliance of a local policy that requires the utilization of US during arterial catheterization. Stakeholders' knowledge deficits of the current policy were analyzed and applied to implement strategies to increase practice compliance.

Ultrasound Guidance

The use of US provides a two-dimensional visualization of real-time guidance into the artery via longitudinal or transverse views. Not only does US help to localize the radial artery and sheath size, but color flow via Doppler also helps to distinguish the vessel from other structures (Yadav et al., 2013). The Allen's test, though debate for reliability, provides a subjective assessment from the CRNA to simultaneously occlude the radial and ulnar arteries then by releasing one at a time for patency of circulation. The Doppler function of the ultrasound is particularly useful in identifying both radial and ulnar arteries for collateral arterial blood flow to the hands. The advantages in using US over other techniques is that it visualizes anatomy, measures flow velocities, and provides observation of directional blood flow after radial artery compression (Oliveira, Danski, & Pedrolo, 2016). Once visualization of the artery is confirmed, the two-dimensional images provide continuous imaging for appropriate advancement through the vessel wall leading to successful arterial cannulation. Aouad-Maroun, Raphael, Sayyid, and Farah (2016) conducted a meta-analysis that found the utilization of US produces increased first attempt success rates (Aouad-Maroun, Raphael, Sayyid, & Farah, 2016). Additionally, authors revealed fewer complications such as hematoma and increased first-attempt success rates compared to the traditional palpation technique. Four studies were conducted including 404 catheters, risk ratio 1.96, 95% with a confidence interval of 1.34 to 2.85 (Aouad-Maroun et al., 2016). Improved success rates were also found within two attempts (RR 1.78, 95% CI 1.25 to 2.51, 134 catheters, two RCTs, moderate-quality evidence) with the use of US guidance compared to other types of guidance (Aouad-Maroun et al., 2016). Another randomized control trial performed by Gu et al. (2014) enrolled 546 patients who met the appropriate inclusion

criteria for radial artery catheterization via US. The study resulted in significantly reduced mean attempts to success (weighted mean difference (WMD) -1.13, 95% CI -1.58 to -0.69), mean time to success (WMD -72.97 seconds, 95% CI -134.41 to -11.52), and incidence of the complication of hematoma (RR 0.17, 95% CI 0.07 to 0.41) (Gu, Tie, Liu, & Zeng, 2014). Finally, a randomized comparative study on 84 children was performed. Some 43 children were randomly placed under traditional palpation technique and 41 placed under US technique. The total success and first attempt rates for the ultrasound-guided group were significantly higher than those of the later. The first attempt success rates for those under US guidance was 60.6% whereas 29.4% under the traditional palpation approach (Anantasit, Cheeptinnakorntaworn, Khositseth, Lertbunrian, & Chantra, 2017). Hematoma complications among those under US guidance resulted in 12.2% versus 53.5% from traditional techniques (Anantasit et al., 2017). The significance behind these systematic reviews and randomized control trials proposes the routine use of US for radial artery cannulation in such cases. The aim is to decrease patient complication risks during arterial cannulation while complying with the policy within the operating room at a local facility within Tucson, AZ.

CONCEPTUAL FRAMEWORK

The Iowa model will assist the CRNA in a road-map-approach with implementing emerging developments into practice within the operating room. The Iowa model (Appendix A) empowers staff members to question current health care practices for arterial cannulation and to investigate if innovative techniques will improve patient care through up-to-date research discoveries. The Iowa model is centered on “problem-focused triggers,” ultimately leading to

staff inquiry of current nursing practices which can be improved by current research findings (Doody & Doody, 2011).

Problem-Focused Triggers

The first step is to select a clinical problem that requires priority within the organization. For this project, the problem identifies those patients who require hemodynamic monitoring with arterial catheterization, who may undergo multiple puncture attempts with the traditional palpation technique. For example, an informal assessment has been completed on the routine use of ultrasonography within a local facility in the operating room for arterial catheterization. The principle investigator (PI) observed numerous arterial cannulations with the use of the traditional palpation method and Seldinger technique over an eight-week period. The use of US was never considered despite multiple puncture attempts. An "attempt" is referred to as the advancement of the needle through the skin to deploy the catheter into the arterial vessel. A failed "attempt" is described as the unsuccessful cannulation of the catheter, absent waveform, or the unsuccessful draw of arterial blood from the catheter. This can be related to but is not limited to anatomy of the vessel, patient comorbidities, vasospasm, and/or hematoma. Furthermore, some patients had comorbidities such as coronary artery disease, atherosclerosis, hypovolemia, all of which can severely hinder successful cannulation of the artery. Case reports have proven the efficacy of ultrasound-guided radial artery catheterization was even more superior in patients who suffer from such conditions as anatomic variation, critically injured patients, edematous and pulseless, and hypotensive patients (Gu, Tie, Liu, & Zeng, 2014). This assessment substantiates an urgent need for necessary changes in current practice among CRNAs. To minimize the incidence of complications, the practice of using US will improve first-attempt success during arterial

cannulation. The second step requires composing of a team who is responsible for the development, implementation, and evaluation of the intervention (Doody & Doody, 2011). The team is made of stakeholders that include caregivers who place arterial lines, attending anesthesiologist, and CRNAs. A practicing anesthesiologist in the operating room takes on the role as a champion who will ensure that staff is informed of the project. This approach is essential as change is more successful when initiated by those practitioners who undergo day-to-day practice within the operating room (Doody & Doody, 2011). The third step involves the retrieval of evidence through specific electronic databases. Systematic investigation of evidence from literature proving the usefulness of US was achieved by searching PubMed and the Cochrane Library. Medical Subject Headings (MeSH) terminology was applied to narrow search results. Additionally, a current clinical practice guideline (CPG) found from the former, National Guideline Clearinghouse (NGC) is referred to as the basis for a need for additional recommendations for utilization of US with arterial catheterization. Similarly, the local facility targeted for this project has a current policy in effect requiring the use of US during arterial cannulation. The policy requirement incorporates, "assessing vessel with ultrasound" and "inserts line … at a 30° to 40° angle using ultrasound guidance" (Appendix A) (Banner Health, 2016). Therefore, the fourth step requires grading of evidence that suggests the non-compliance of the effective policy. This involves the utilization of a content-analysis tool, which gathers qualitative information from each CRNA surveyed on behalf of their knowledge and understanding of the policy. The content analysis tool, *Survey Monkey,* is intended to ask 10 questions that identify specific gaps as to why CRNAs are non-compliant with the use of US during arterial catheterization. Once the rating is completed and the data is aggregated suggesting

identifiable barriers, the fifth stage is underway, which progresses into an evidence-based practice standard within the operating room. The recommendations made should be based on identifiable benefits and risks to the patients (Doody & Doody, 2011). The sixth stage leads to the recommendations and re-implementation of the policy for routine use of US in the operating room. Guidelines and written policy that involve direct interaction between CRNAs, organization, and leadership roles, are designed to provide successful implementation of the innovation, leading to increased compliance (Doody & Doody, 2011). Finally, step seven requires an evaluation of the implementation of evidence into practice (Doody & Doody, 2011). It is helpful to ascertain baseline data prior to implementation as it will provide evidence that contributes to a change in compliance with the current policy. The Iowa model requires an effective team to apply the evidence to practice, evaluate its delivery, and a process involving multiple steps to align clinical behaviors for a positive change in policy compliance (Rycroft-Malone & Bucknall, 2010). Under the direction of this model (Figure 1), it is important to decide if this topic is a priority for this facility.

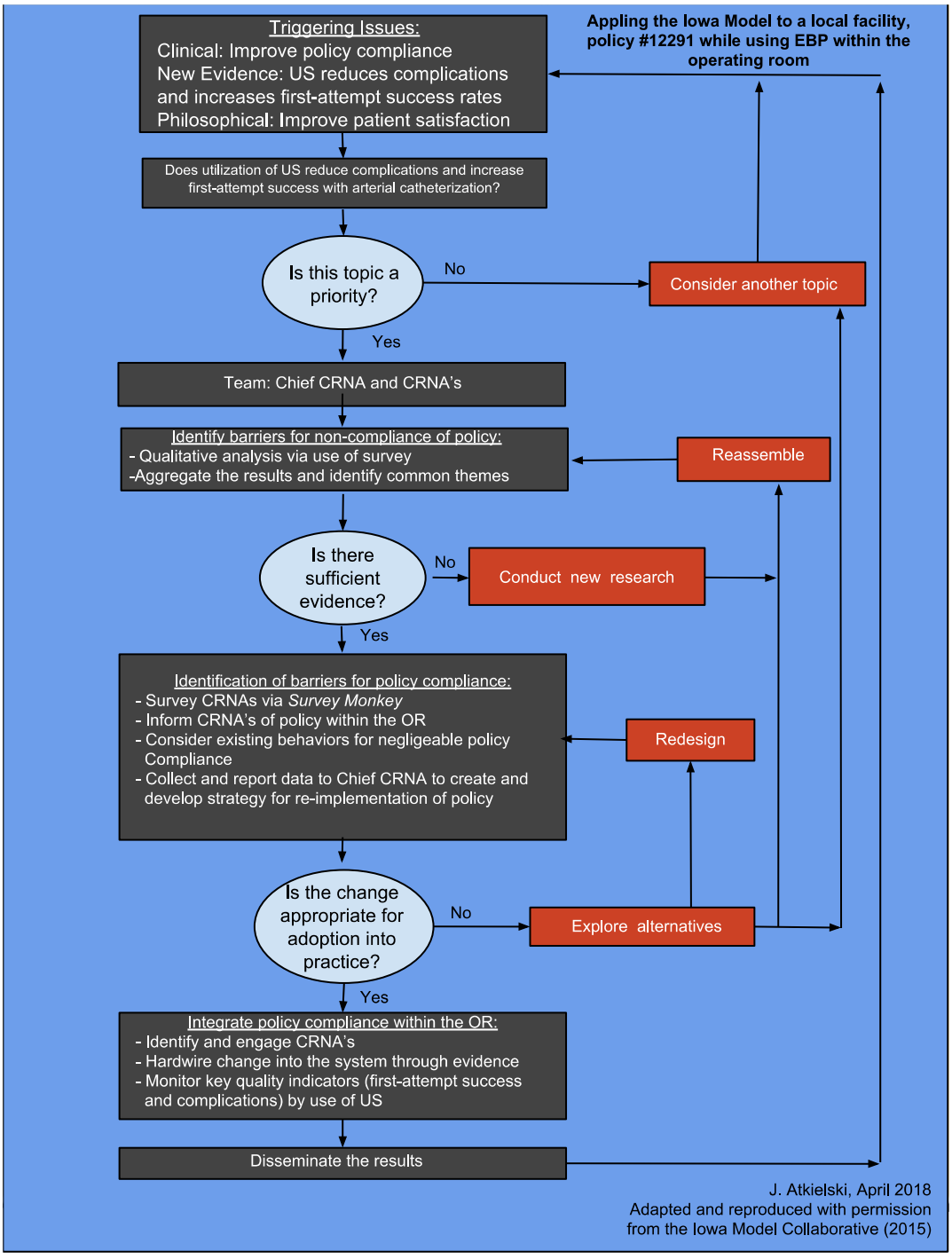


FIGURE 1. Adapting the Iowa model to a local facility. (*Used/reprinted with permission from the University of Iowa Hospitals and Clinics, copyright 2015. For permission to use or reproduce, please contact the University of Iowa Hospitals and Clinics at 319-384-9098.)*

LITERATURE REVIEW

Question

In a local facility located in Tucson, AZ, will the identification of barriers for CRNA compliance of policy *#12291, Radial & Brachial Arterial Catheter: Insertion, Maintenance, and Removal*, change behaviors among CRNAs resulting in its adoption for practice?

Literature Search

At a local facility, through informal observation, it has been identified that most arterial lines are placed within the operating room without the use of US. Although no formal surveys have been conducted to substantiate this point, casual conversations among CRNAs elude to minimal to no use of US with arterial catheterization. This often leads to multiple puncture attempts ultimately resulting in vasospasm, hematoma, and/or increased risk for infection. When the number of failed attempts increase from traditional palpation techniques, the utilization of US is then considered as a rescue attempt. Literature to support a practice change will emphasize the importance for compliance of this policy.

Search Criteria

The publications were organized and compared via the use of an appraisal table, source grid (Appendix D). The first pathway involved a search in PubMed and Cochrane Library. There were no language restrictions and a five-year publication date was recommended, yielding 231 articles. These articles were based on meta-analysis, systematic reviews, and randomized controlled trials (RCT) of not only arterial cannulation with the use of ultrasound, but also various other topics. The electronic searches were exploded using Medical Subject Headings (MeSH) terminology. The specific terms/phrases applied to MeSH included *radial artery* and

ultrasonography. The term, *catheterization* was also added to MeSH for further narrowing, which yielded 108 articles. A thorough review of the 108 articles yielded 12 articles, 10 of which have been synthesized.

Clinical Practice Guideline

The second pathway consisted of a writing committee who were assigned to specific recommendations from a current CPG. The interest behind the CPG is to establish evidence-based guidelines for the use of bedside US by specialized practitioners for interventional guidance (Frankel et al., 2015). The NGC is home for the *Guidelines for the Appropriate Use of Bedside General and Cardiac Ultrasonography in the Evaluation of Critically Ill Patients-Part I: General Ultrasonography.* This guideline was developed by the Society of Critical Care Medicine – Professional Association and released in November 2015. The articles were reviewed and scored on a basis of three levels of quality using the Grading of Recommendations, Assessment, Development, and Evaluation (GRADE) system.

SYNTHESIS OF EVIDENCE

Strengths

In the articles by Shiloh et al. (2011), Yan-Bing et al. (2015), Seto et al. (2015), and Wan-Jie et al. (2016), study participants underwent arterial catheterization using US guidance and traditional palpation techniques. The two techniques were compared and evaluated with their proficiency in first-attempt success rates. The aggregated results of these studies recommend that with the use of US, first-attempt success had a significant improvement compared to the traditional palpation technique. Wan-Jie et al. (2016), also found a considerable decrease in the occurrence of hematoma and complications attributed with US. Interestingly, 10 patients who

underwent the palpation method required a crossover to US guidance after five minutes of failed palpation attempts, resulting in successful cannulation with US. According to one meta-analysis, the use of US during cannulation offers increased success rates on first-attempt punctures (Aouad-Maroun, Raphael, Sayyid, & Farah, 2016). A second meta-analysis showed, with the utilization of the US, fewer complications such as hematoma resulted (RR 0.20, 95% CI 0.07 to 0.60, 222 catheters, two RCTs, moderate quality evidence) (Aouad-Maroun et al., 2016). Further, the American Society of Echocardiography recommends ultrasonography to improve the first-pass success of radial artery cannulation (Marquis-Gravel et al., 2017). These articles provide substantial evidence as to why the current facilities policy requires full compliance by its CRNAs.

Weaknesses

In a parallel RCT by Kiberenge et al. (2018), a meta-analysis by Aouad-Maroun et al. (2016), a non-blinded RCT by Abdalla et al. (2017), all recognize that US offers advantages over traditional palpation technique. Moreover, modified US techniques were explored with each of these studies that provide insightful findings. Different US techniques that were investigated were the oblique view, which is a modified US probe placement, dynamic needle tip view which incorporates both the short- and long-axis techniques, and the use of Doppler for radial artery catheterization. Three of the four authors found that modified views using US provided better visualization of the radial artery, therefore increasing first-pass success rates. However, Ueda at al. (2015) found that subjects were excluded who had inflamed skin near the puncture site, mottled, cooled skin with poor capillary refill, and had been punctured within the previous 30

days. The randomization of internal validity is skewed as specific US techniques, may prove to be more successful than others in such cases.

Gaps

Control of the study involves integration of conditions on the research so that biases are minimized and precision and validity are maximized (Polit & Beck, 2017). Gaps such as scientific rigor, training for proficient use, mean attempts, time to success, and incidence of complications like hematoma and comorbidities are not always acknowledged or are omitted within the study. For example, in the RCT by Marquis-Gravel et al. (2017), an assessment of US guidance compared to traditional palpation approach in patients who require femoral artery access for coronary angiography was performed. Although the data depicted a decrease in bleeding events, multiple puncture attempts, and venipunctures with US use, successful femoral artery cannulation was not improved. Similarly, in the prospective single-center prospective trial by Zaremski et al. (2013), operator experience of the US may have had a correlation with placement during catheterization. This study showed that arterial line placement by experienced cardiac interventionist using US, provided no substantial benefit over traditional palpation technique. It is cited that one operator decided to abandon the radial location mainly due to the observation of "an unsuitable radial-artery." These examples can cause heterogeneity within the review potentially influencing the overall results. Circumstances such as these provide credence that the utilization of US needs to be recommended for routine use, especially since direct visualization of the vessel provides meaningful evidence for catheterization.

Findings that resulted from the search have raised interests that require further investigation. Careful comparison with each synthesis will prove to benefit a robust analysis.

Moreover, large-scale studies with improved designs should be conducted to continue to challenge current findings, which would strengthen the adoption of US utilization during arterial cannulation and increase policy compliance.

METHODS

Design

The purpose of this DNP project was to work with local stakeholders to identify barriers for compliance of local policy for arterial cannulation in patients who require invasive hemodynamic monitoring by incorporating the use of US. Thus, a 10-question survey that includes both open- and closed-ended questions is utilized to identify barriers for use of US when attempting arterial catheterization. In response, identification for CRNAs' compliance of the local facilities policy is elicited. Moreover, *Policy #12291: Radial & Brachial Arterial Catheter: Insertion, Maintenance, and Removal*, which is currently in effect and revised as of September of 2016, is assessed in a qualitative approach for content analysis. The specific tool for analysis, *Survey Monkey,* is a qualitative approach to assess CRNAs for an annual approximation of the total number of arterial lines placed, knowledge of current policy, and reasoning why or why not their utilization of US during arterial catheterization. Prospective participants received an email correspondence (Appendix F), which included a short description of the project and time frame for completion. Email addresses for each CRNA were placed with the *Survey Monkey* tool and sent with a link to complete the survey. Anonymity is vital throughout the survey process. *Survey Monkey* utilizes software that retains the confidentiality of the surveyed, which is especially conducive to anonymity. The goal was to have a 30% response rate within the predetermined timeframe for content analysis.

Setting

A non-profit, Level-1 hospital in Tucson, Arizona, served as the setting for this project. This local facility upholds certain values that include serving the community with their health-care needs. They strive to provide clinical excellence through evidence-based practice and best practice while upholding supportive education. While their standards are high, compliance is of utmost importance, striving for practitioner compliance with the use of up-to-date clinical practice guidelines. The project commences in the setting of the operating room. There are currently four US machines available and are located within the OR department. For successful implementation of this project, stakeholders include the chief attending anesthesiologist, nurse circulators, CRNAs, and anesthesia technicians. More importantly, under the guidance of the PI, the Chief CRNA has provided availability and support with the course of this project.

Participants

Certified registered nurse anesthetists who place arterial lines were the targeted population for this project. Despite their use of traditional landmark and palpation techniques, anesthesia providers will understand the evidence to support a change in current practice and the importance of the routine use of US with arterial catheterization. As best practices evolve into clinical practice, tools have been designed to appraise CPG's on a national level. For example, the Agree II instrument was developed to assess the quality of a CPG and how persuasive interventions can be (AGREE Next Steps Consortium, 2009). The guideline is assessed by up to four appraisers as this increases the reliability of the assessment. Similarly, the concept of using *Survey Monkey* provides the necessary evidence required to identify barriers for policy compliance at this facility. A convenience sample was used that utilized the most conveniently

available CRNAs within the OR of the facility. Approximately 25, full-time CRNAs work within the OR at the local facility and were encouraged to participate in completing the survey. A flyer (Appendix G) was posted within the breakroom of the facility that provided the aim for this project and notable deadlines for participants. Prospective participants were assured that their involvement was private and protected through the email correspondence. The survey period expired one week after the initial correspondence was made. The criteria for inclusion included those CRNAs who were qualified in placing invasive arterial monitoring catheters via traditional and US techniques. Increasing success with cannulation involves appropriate vessel assessment, significant technical skill, and manual dexterity (Reeves, Morrison, & Altimiller, 2017). In addition, the surveyed must be familiar with using the computer and navigating through each of the 10 questions. Furthermore, the aim of this study was to identify the barriers for compliance of this policy, which will suggest strategies for compliance among CRNAs leading to the use of US during arterial catheterization.

Data Collection

To identify barriers for compliance that exist in this medical facility, conversations between the PI and Chief CRNA provide meaningful direction for data analysis. Data obtained from these conversations were used as an aid to emphasize the importance of policy compliance. The next step was to find and evaluate the policy and any other materials that were helpful for dissemination to CRNA's. After a search on the facilities website for "policy 12291," the policy in its entirety was found to be fully viewable to all employees (Appendix A). Additional information was found in power point presentation format that included a step-by-step method, according to policy, on how to perform the arterial line procedure. Both references required the

use of ultrasonography during the procedure of arterial catheterization, however, CRNA's are non-compliant to its use. To identify barriers for compliance, the use of a tool for content analysis was used.

Survey Monkey

Survey Monkey is an online survey tool that is developed on a cloud-based software platform that allows users to design, customize, eliminate bias, and analyze data. The development of 10 questions were appropriately designed to achieve data that would be helpful to present common themes contributing to non-compliance of the policy (Appendix E). The first multiple-choice question included the CRNA's years of experience. The motivation behind this question is to correlate skill with length of practice time. The second question was designed to capture how many arterial line placements are being conducted on average over one year. A slide bar from 0-100 was used to approximate these numbers. The third question entailed a series of cases that the surveyed would consider required the need for arterial catheterization. The intent here is to identify similarities among CRNA's on what cases should receive arterial lines. The fourth question asked if the CRNA was aware of the facilities policy #12291. Answer choices included "yes" or "no." The fifth question was to ask if the CRNA viewed the policy. This was designed to follow up with the fourth question since it simply asked if they were aware of the policy. The sixth question involved the reasoning why "have" or "have not" the CRNA viewed the policy. The significance of this question was to identify system failures, lack of knowledge of the policy, or simply no interest in understanding the policy. The seventh question identified if the CRNA received training for the use of US. The answer options included "no" or "yes" and to explain the type of training if answered "yes." The eighth question asked if the CRNA practices

the routine use of US when performing arterial catheterization. This was to identify actual raw data and frequency of its use. The ninth question asked for the reasoning as to "why" or "why not" the use of US. The motivation behind this question was to draw out potential barriers of noncompliance. Finally, the last question was to achieve how many arterial lines the CRNA has placed with US within the last month. Overall, the content analysis was effective since it aided as to what barriers were identified for the negligible use of US during arterial catheterization. The participants were encouraged to contact the PI with any other questions they may have had throughout the evaluation period.

Plans for Data Analysis

Responses from each question are analyzed using the specific functions within the *Survey Monkey* tool. Additionally, responses are aggregated and placed into percentages for easy appraisal of evidence. The qualitative data results are then inserted into a "word cloud" program. Word clouds are graphical representations that emphasize words that are used most frequently within the content analysis survey. More specifically, the larger the word within the visual representation, the more common the term was used by the surveyed. These visualizations can provide researchers with textual analysis by identifying common themes or problems that may exist. Word cloud is applied to this project for data analysis to explicitly identify the barriers as to the non-compliance of *Policy #12291* by CRNA's. These findings will result in strategies to improve notification of the policy and/or improve practice among CRNA's for utilization of US.

Ethical Considerations

This project met all institutional review board (IRB) criteria and received approval deeming this project is ethical. The facilities Non-Research Determination Utilization Committee

(NRDUC) determined the projects feasibility and is congruent with its initiatives. This project was conducted and considered non-research.

Respect for Persons

In this case, CRNAs were recruited to participate in the analysis to identify compliance of policy requiring the use of US when placing arterial lines. Consent to participate was sought and anonymity protected via de-identified participation in by use of the content analysis tool.

Beneficence

Beneficence is the process that includes CRNAs to help or benefit the patients according to their best judgment to weigh the risks versus benefits for a subject to participate (HHS, 2018). The use of US with arterial catheterization will help "to do good" and "do no harm" for patients who need arterial lines for hemodynamic monitoring.

Justice

Justice incorporates who should receive the benefits of research and how it is distributed equitably. This project will provide the anesthesia department at the local facility in Tucson, Arizona with increased compliance of the policy #12291 that was developed with the input of local providers. The confounding analysis from this project and non-compliance among CRNAs of this policy will lead to strategies for re-dissemination if they so desire.

RESULTS

Data Analysis and Outcomes

Studies have demonstrated that with the innovation of ultrasonography, the visualization via two-dimensional imaging yields increased first-attempt success rates with arterial catheterization. In contrast, multiple attempts via the use of the traditional landmark method result with an increased risk of hematoma and arterial spasms (Anantasit, Cheeptinnakorntaworn,

Khositseth, Lertbunrian, & Chantra, 2017). A local facility in Tucson, Arizona has a current policy in affect that requires the use of ultrasound with radial/brachial arterial catheterization. An informal observation conducted by the principal investigator revealed the attempt of several arterial catheterizations without the use of US. Thus, the motivation behind this project is to identify barriers as to why CRNAs are noncompliant with the policy requiring the use of ultrasound during arterial catheterization.

A concept analysis approach was used to analyze barriers, leading to improvement strategies for policy compliance among CRNAs. A survey was created using the online tool, *Survey Monkey*, which posed 10 questions to CRNAs pertaining to years of experience, current policy requirements, utilization of US, and why or why not the use of US with arterial catheterization. An email approved by the IRB was sent to a convenient sample of 25 CRNAs who work within the operating room at the local facility. The correspondence explained the aim of the project as well as the importance of anonymity for those being surveyed. Each of the 25 CRNAs' email was added to the *Survey Monkey* tool and distributed after the initial correspondence was sent. The CRNAs had one week from time of distribution to complete the three-minute survey. A goal of 30% participation was set for meaningful analysis.

Data Analysis

Once the survey closed, a total of 13 CRNAs had participated in the survey, equating to 52% of the convenience sample. The responses to each of the 10 questions were analyzed via the "analyze results" function tab within the *Survey Monkey* tool. Seven non-open-ended responses were aggregated and placed into a data trend graph for interpretation of results. Three open-ended responses were placed into tables for narrative interpretation and inserted into the *Word*

Cloud application. The *Word Cloud* software is designed to rate increased word frequency with larger font size. Each response was added to *Word Cloud*, and filtered by using the "word list" function to omit irrelevant words.

The first question was designed to ascertain the number of years of anesthesia experience among CRNAs. The responses resulted with 69% who have 0-5 years of experience. Whereas, 7.7% of respondents had 6-10 and 11-15 years of experience. There were no responses for those CRNAs who had 16-20 years but 15.4% of respondents had 21+ years of experience. This is important as it sets the stage, providing a wide range of experience for those who participated in the survey. Also, on-the-job experience may be suggestive for the use or non-use of ultrasound depending on specific barriers CRNAs have had over the years when placing arterial lines. These variables could have potentially led to misleading results from the surveyed and are mentioned in the following section. The second question provided a total, approximate number of how many arterial lines are placed annually among CRNAs. Of the 13 who responded, the average number of arterial lines placed annually resulted in 36 respectively, with a total number of 473. This suggests that there is a considerable number of arterial lines placed annually within the local facility. Furthermore, the increased potential for complications with arterial catheterization while using the traditional landmark method can result in unfavorable outcomes. One study suggested catheter-related infection and inflammation were the most prevalent complications associated with arterial catheterization, which resulted in 6.9% of patients and 62% of all complications (King, Garrison, Vavilala, Zimmerman, & Rivara, 2008). Question number three further evaluated specific cases in which CRNAs would place arterial catheters. All 13 of the surveyed responded that craniotomy, trauma, and thoracotomy warranted an arterial line. Cases such as

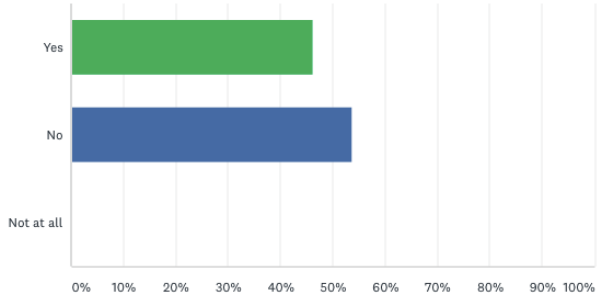
vascular, cardiovascular, and transplant consisted of 92.3% of the respondents who believed an arterial line was necessary. Spine cases resulted in 84.6% of respondents and ENT, morbid obesity, and orthopedic cases resulted with the insignificant likelihood for the CRNA to place an arterial line.

The next set of questions relate to the local facilities policy for the use of US with arterial catheterization. Question four (Table 1) inquired if respondents were aware of the policy, *Radial & Brachial Arterial Catheter: Insertion, Maintenance, and Removal Policy #12291*. Of the 13 who answered this question, 46.2% responded "yes" and 53.9% responded "no."

TABLE 1. *Question 4 responses.*

Are you aware of the facilities policy, Radial & Brachial Arterial Catheter: Insertion, Maintenance, and Removal Pol #12291?

Answered: 13 Skipped: 0



ANSWER CHOICES	RESPONSES	
Yes	46.15%	6
No	53.85%	7

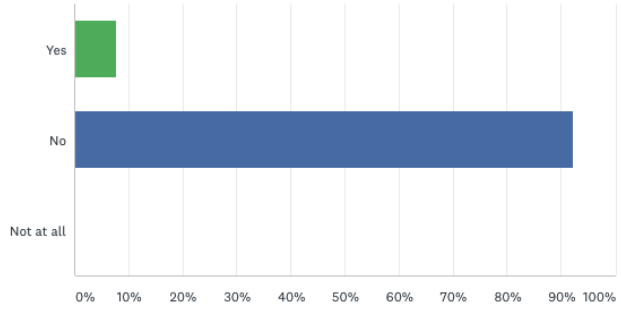
More than 50% of the surveyed were unaware of the facilities policy. On the contrary, just under 50% of respondents identified that there was a policy for arterial catheter insertion. Specifically, those who are aware of the policy may be unaware of its line-by-line requirements. In addition to the policy, employees of the facility have access to a guide via power point

presentation on steps to follow when placing arterial catheters. For example, question five queried the 13 respondents if they have viewed *Placing Peripheral Arterial Catheters* power point presentation, which is available on the facilities Intranet (Table 2).

TABLE 2. *Question 5 responses.*

Have you viewed Placing Peripheral Arterial Catheters Power Point Presentation available on the facilities Intranet?

Answered: 13 Skipped: 0



ANSWER CHOICES	RESPONSES	
Yes	7.69%	1
No	92.31%	12

An astounding 92.3% of the surveyed had not viewed the presentation on arterial catheterization. A question for follow-up, would be to address CRNAs if they have been informed of such presentation and how it assists them for policy compliance. The sixth question which was open-ended, asked the CRNA to provide reasoning as to, why have they or have not viewed the policy. Of note, there were eleven respondents who participated and two of which who skipped this question. Table 3 provides responses for each of the 11 CRNAs who participated in this question.

TABLE 3. Question 6 responses.

CRNA Participants (1-11)	Have Viewed Policy	Have Not Viewed Policy	Unknown if Viewed Policy	Viewing of Policy Narrative
1			X	"The method I use works well, is aseptic, and I have not seen any need to change practice."
2		X		"Unaware that was available."
3		X		"I am aware of what it states so I have not viewed it."
4		X		"I was not aware it existed."
5		X		"I was not aware that there is a policy in place regarding details of placing peripheral arterial catheters. I am comfortable in my skill level in placing arterial catheters and did not proactively search for a policy."
6		X		"Because I did not know it existed."
7		X		"Didn't know it existed."
8		X		"I did not know it existed."
9		X		"I wasn't aware of the policy."
10		X		"I don't routinely look at policies and am unfamiliar with where they are located."
11		X		"Not required, not mentioned."

The responses reflected a lack of knowledge of a policy that exists or that is required for viewing. This table identifies that 91% of respondents have not viewed the policy on arterial catheterization. It is not clearly understood if participant 1 has viewed or has not viewed the policy according to the narrative provided. Furthermore, the narrative implies that perhaps even after viewing of the policy there would be no change in CRNA policy compliance. The responses were further inspected and placed within the *Word Cloud* tool (Figure 2) to emphasize common themes among those who responded.

FIGURE 2. Word cloud analysis for question 6.

The *Word Cloud* depiction uses words within the concept analysis narrative and increases specific word font size based on how frequent those terms were used. The terms such as "existed," "policy," "aware," "know," "placing," etc. were mentioned most frequently among respondents, therefore identifying a major barrier to policy compliance.

The final set of questions within the survey are directly associated with the use of ultrasound with arterial catheterization. Question seven asks the respondent if they have received training for the use of ultrasound and if so, to explain the nature of training. Of the 13 who responded to this question, 84.6% expressed that they have received some sort of training for the use of ultrasonography. Table 4 provides a narrative as to what sort of training the CRNA received.

TABLE 4. *Question 7 responses*.

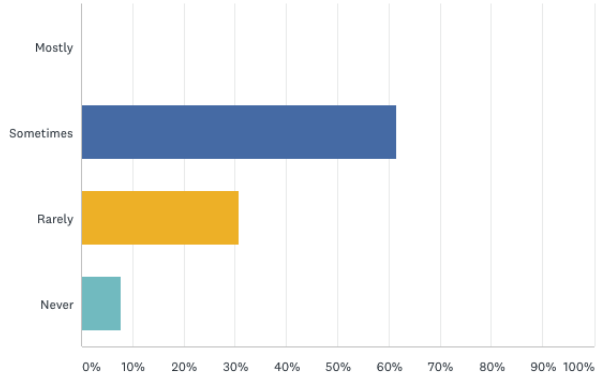
CRNA Participants (1-11)	Training on US Narrative
1	"Some ultrasound training in school."
2	"General training in CRNA school."
3	"During CRNA school."
4	"Yes, anesthesia school."
5	"CRNA school included a short unit on ultrasound use."
6	"On the job training."
7	"Not a formal class, just observing other providers."
8	"Conference on blocks."
9	Hands-on in CRNA school at different training locations as well as skills days in school."
10	"Clinical training when I was a student."
11	"Currently a CRNA and was part of training/clinical requirements."

The narratives suggest that 64% of CRNAs received their ultrasound training in CRNA school. The other respondents received their training either from on-the-job training or from a "conference on blocks." One CRNA disclosed that they had not received formal training, only observed other providers performing the catheterization. One article suggests that 15 arterial catheterizations is required prior to becoming "proficient" with its utilization (Seto, Ultrasound guidance for radial access: Getting in the first time, 2012). The eighth question identified the routine utilization of ultrasound when performing arterial catheterization among CRNAs. Table 5 is a graphical depiction of the 13 respondents and their resolutions.

TABLE 5. Question 8 responses.

Do you practice routine utilization of ultrasound when performing arterial catheterization?

Answered: 13 Skipped: 0



ANSWER CHOICES	RESPONSES	
Mostly	0.00%	0
Sometimes	61.54%	8
Rarely	30.77%	4
Never	7.69%	1
TOTAL		13

Most of the respondents (61.5%) disclosed that they use US with arterial catheterization "sometimes" and 30.8% of respondents used US "rarely." Only one CRNA suggested that they "never" used US for arterial catheterization. Perhaps the reasoning behind why one respondent answered "never" is because they pass it off to another provider if they are not successful within a reasonable attempt. Question nine queries the CRNA regarding an explanation as to why or why not they use US for arterial catheterization. Table 6 provides the qualitative data in narrative form for interpretation.

TABLE 6. *Question 9 responses*.

CRNA Participants (1-13)	Why Use US	Why Not Use US
1	"If there is difficulty I would move to using the ultrasound."	"I have not found any difficulty in placing an arterial catheter in without an ultrasound."
2		"Don't use it if patient has good pulses."
3	"If I believe it will be difficult to place without ultrasound."	"It depends on the patient's pathophysiology."
4		"Ultrasound not easily accessible or available in the OR."
5	"I typically only use an ultrasound if either: I do not feel a bounding pulse, the pt has a hx of PAD, or there has been an unsuccessful attempt (by me or another provider) in placing the line."	
6	"If they have a weak pulse, PAD, or if I'm doing it in pre-op, I start with u/s."	"If I feel confident in first pass success rate while the patient is under GA I will not always go to the u/s first."
7		"Using another piece of equipment isn't always necessary."
8		"Trained without use of US."
9		"I will not always be in a facility that requires the use of US for arterial catheterization. Therefore, if I feel I may be successful at placing an arterial line without US, I will attempt the placement."
10	"If I have difficulty I will attempt with the ultrasound."	"I will try to place the line first…there are limited ultrasound machines available."
11		"I feel comfortable in most cases placing one without the ultrasound. Often the ultrasound is being used."
12	"If the patient pulses are weak, I will use ultrasound."	"When the pulse is palpable, I do not use ultrasound."
13		"No longer proficient in using US and US not always available."

The comparison between the two suggests that the CRNA utilizes their clinical expertise case by case to determine whether the use of US is worthy. For example, those who use the US have determined that either the pulse is weak, the patient has history of peripheral artery disease, or previous failed attempts with the landmark method. Figure 3 is a depiction of how frequent words were used in question nine. Terms that are noteworthy include: "available," "feel," "difficulty," and "attempt," all of which speak to clinical criteria for the use of US. Furthermore, respondents referred to the ultrasound's lack of "availability" and "accessibility" for CRNA utilization. Remarkably, not one time did a CRNA suggest they used US because a policy

required them to. In contrast, much of CRNAs do not use the US when the radial pulse is palpable, bringing a “comfort” level for successful landmark catheterization. Others suggest that the use of US may be dependent on the patient’s pathophysiology. This requires the CRNA to make an informed decision from their initial assessment whether the patient is a good candidate for traditional landmark method versus the use of US. Interestingly, four responded that the reason why they do not use US is that the machine is unavailable. This poses as a barrier that there are not enough resources available to obey a policy requiring CRNAs to use US with arterial catheterization.

FIGURE 3. Question 9 word frequency.

Finally, question 10 queried CRNAs as to how many arterial lines they have placed under the guidance of ultrasound within the last month. Of the 13 CRNAs who responded, 53.9%

suggested they hadn't placed any arterial lines under ultrasound guidance and 46.1% responded to have placing 1-5 arterial lines under ultrasound guidance. With the evidence that has been ascertained, a follow-up question is warranted to understand the reasoning behind the use of US. However, the narrative data from question nine would suggest the reasoning behind its use is due to patient pathophysiology, peripheral vascular disease, and/or failed attempts with traditional landmark method. An analysis comparing the years of CRNA experience and the use of ultrasound would be a worthy assessment to evaluate any correlation that could identify gaps in policy compliance with specific groups of CRNAs. Unfortunately, this survey does not directly correlate years of experience to utilization of US with arterial catheterization. If analysis was performed with this projects' survey results, two of the respondents answered having 21+ years of experience. This survey encompasses 25 CRNAs, three of which can be identified of having 21+ years of experience. This would breach anonymity, further leading to an ethical consideration.

Impact of Results

The results attained from the survey suggests a wide range of CRNA demographics including varying years of clinical experience, similar thoughts as to which cases require arterial lines, and an average of 36 arterial catheters placed annually per CRNA. In addition, the survey demonstrated that 54% of CRNAs are unaware that a policy exists for use of US with arterial catheterization. Policies within healthcare facilities exist to serve the needs of all members of the organization as well as assist in compliance with regulatory and accreditation requirements (O'Donnell & Vogenberg, 2012). Policies are determined by regulations and standards of practice that have been decided by executing bodies within the facility. A policy designed to use

US with arterial catheterization not only would be in place so CRNAs have direction with such procedures but more importantly, reduces the likelihood of causing harm to patients within the facility. Another alarming barrier, is that 46% of CRNAs are aware of an existing policy that requires the use of US, however they are reluctant to follow it. The identification that CRNAs are noncompliant with this policy requires an immediate need for recourse. A third barrier identified was 31% of respondents suggest that the US was unavailable for use. This warrants attention from administrative personnel to ensure required resources are available for use. Therefore, strategies that realign policy with CRNA practice will provide meaningful results with its compliance. Practice behaviors and sustainability of policies are directly related to strategies for implementation.

DISCUSSION

Strengths

The evidence from the survey suggests that the use of US with arterial catheterization is used in a "rescue" attempt rather than a "primary" attempt. One can interpret this as many CRNAs recognize the benefits that ultrasound can offer. They understand that having direct-visualization of the vessel and surrounding structures is advantageous when cannulating a vessel. The concerning factor however pertains to the reasoning as to why CRNAs avoid the use of US with first attempt. Question nine identified that most CRNAs do not use US when a palpable pulse is assessed. Furthermore, not having US available/accessible for CRNA use, policy or not, acts as a barrier, thus discouraging them for adopting it into individual practice.

Limitations

One point that requires clarification within the survey is the term, “routine.” Some respondents may have misunderstood this question since the term “routine” does not suggest “always.” Perhaps if the question were stated, “Do you always utilize US when performing arterial catheterization,” the results would have differed. Moreover, the term “sometimes” can take on many interpretations. For example, the term may take on more of a “permanent” meaning to one CRNA, but a “periodically” occurrence for another. These differences observed would help to distinguish more permanent use rather than periodic.

Summary and Dissemination

Through current literature synthesized within this project, the utilization of ultrasonography with radial arterial catheterization has attested to increase first attempt success rates while reducing complications. A 10-question survey was conducted among a compliance sample of 25 CRNAs, 52% of which participated in within a current facility. Confounding evidence identified that less than half of all CRNAs in the local facility are aware of a policy that requires the use of US with arterial catheterization. Moreover, CRNAs certainly did not suggest they used US because a policy required them to. This evidence suggests that a re-implementation strategy is required to notify CRNAs that the use of US is a policy requirement within this local facility. The dissemination of evidence from this project will serve as the primary process encouraging CRNAs to reevaluate their own practice when placing arterial lines. The first stage for behavior change requires distribution of evidence on flyers that will be placed within the operating room to account for the importance of this project. Not only will it notify CRNAs that there is a policy but also the importance in first attempt success rates relating to patient safety.

The second stage of dissemination will occur at a higher lever within the operating room department. The Chief CRNA will have access to this information and can further devise a plan for CRNAs to view the policy either in weekly huddles or learning modules. Finally, the project is represented on a state level so that other CRNAs can not only see the importance for complying with local facility policies but also the importance in using US with arterial catheterization. This process will continue as a process improvement project to increase policy compliance within the local facility.

DNP Essentials

The foundational competencies that are required for Doctoral Nurse Practitioner (DNP) graduates regardless of the specialty or focus, are referred to as the *DNP Essentials*. The *DNP Essentials* consist of eight foundational essentials that constitute the major component of DNP programs (AACN, 2006). Three *DNP Essentials* have been applied to this project to exhibit specialized content within the area of advanced practice nursing-nurse anesthesia.

Essential I: Scientific Underpinnings for Practice

Practice as a doctorate in nursing, offers a sound academic preparation towards complexity in practice. Scientific underpinnings from research provide the learners with a knowledge base and an ability to integrate the knowledge efficiently, benefiting the patients in daily practice environments (AACN, 2006). Nursing science has emerged with the development of theories and concepts to assist with nursing practice. Specifically, the Iowa model which served as a conceptual model, was the basic framework within this project. The example of nursing science and the adaptation of the Iowa model, provided a step-by-step approach for meaningful analysis for policy compliance. The “problem-focused triggers” within the Iowa

model allowed the PI to acknowledge a deficit in policy compliance, perform literature search on the innovation of US, compose a team of stakeholders, perform content analysis, and disseminate results for increased policy compliance.

Essential II: Organizational and Systems Leadership for Quality Improvement and Systems Thinking

A doctoral level of knowledge and clinical skills are consistent with health care nursing and goals that eliminate disparities, ultimately promoting patient safety and excellence in practice (AACN, 2006). This essential requires the learner to understand principles of practice management that include strategies that balance productivity with quality of care. For example, the use of US has been identified to meet current and future needs of patient populations, which is based on scientific findings in nursing practice. Quality improvement strategies will be applied to the findings from this project resulting in improved system-wide health care policy, which will improve the quality of practice and care for our patients.

Essential V: Health Care Policy for Advocacy in Health Care

Institutional decision making or designing organizational standards creates a framework that can lead to dissemination or failure of delivery of health care services (AACN, 2006). Moreover, the DNP student engages in processes of policy development or compliance in creating a health care system that meets the needs of its constituents. This relates to strategies such as the assessment of practice policies and procedures that exist within a facility. This project has not only demonstrated the innovation of US and its increase in first-attempt success rates with arterial catheterization but also the identification of noncompliance of a local policy requiring the use of US with arterial catheterization. This assessment will allow leaders within

the facility the ability to organize these practice disparities, thus resulting in an increase in compliance of the policy.

APPENDIX A:

BANNER HEALTH POLICY FOR ARTERIAL CATHERIZATION #12291

Banner Health

Banner Health Critical Behavior Reference (checklist) for Competency Tool
Complete for Employee File ONLY with action plans, RCA's, or other special circumstances

TITLE	**Arterial Line Insertion**					
EFFECTIVE DATE		**DATE REVISED:**	**9/27/2016**	**REVIEWED**	**9/27/2016**	**VERSION #**
SKILL LEVEL:				**DEPARTMENT**	**Vascular Access Team**	
ASSOCIATED POLICY & PROCEDURE IF APPLICABLE	*Radial & Brachial Arterial Catheter: Insertion, Maintenance, and Removal Pol #12291*					
FACILITY	**BTMC**					

Employee Name: _____ **Employee Number:** _____

☐ **Initial Review** ☐ **Annual Review**

Age Population: Adult & Geriatric

	CRITICAL ELEMENTS	Competency Met By:
1.	Verifies Physician's order.	☐ Direct Observation ☐ Return Demonstration
2.	Gathers Equipment	
3.	Explains procedure and rationale to patient	
4.	Performs Modified Allen's test & assess vessel with ultrasound	
5.	Performs 1% lidocaine infiltration if appropriate and patient not allergic (may be once sterile field set up)	
A.	Positions the hand with support and dorsiflexes the wrist at approximately a 60° angle (a rolled wash cloth or towel beneath the wrist will help to maintain the position)	
B.	Prepares site with Chloraprep, using a back and forth motion. If patient is allergic to chlorohexadine, use alcohol only.	
C.	Prepares sterile field	
D.	Applies sterile gloves	
E.	Palpates the radial artery to determine exact location	
F.	Inserts line into site keeping catheter/needle at a 30°-40° angle using ultrasound guidance	
G.	Observes for blood return, then threads catheter while maintaining needle position	
H.	Remove needle/guide wire leaving catheter in vessel	
I.	Connects end of catheter to extension piece/stopcock	
J.	Cleans insertion site and hub of blood	
K.	Secures line with securement device, sterile transparent dressing, BioPatch (if applicable)	
L.	Bleeds air out of extension piece/stopcock & connects to pressure tubing	
M.	Connect to monitor and arterial waveform	
N.	Sets blood pressure alarms on monitor	
O.	Performs square wave test	
P.	Documents procedure (number of attempts, etc.)	

Banner Health Critical Behavior Reference (checklist) for Competency Tool
Complete for Employee File ONLY with action plans, RCA's, or other special circumstances

Employee Must Demonstrate Five Successful Insertions for Validation Criteria to be met:

Validated By:_____Date: _____

Validated By:_____Date: _____

Validated By:_____Date: _____

Validated By:_____Date: _____

Validated By:_____Date: _____

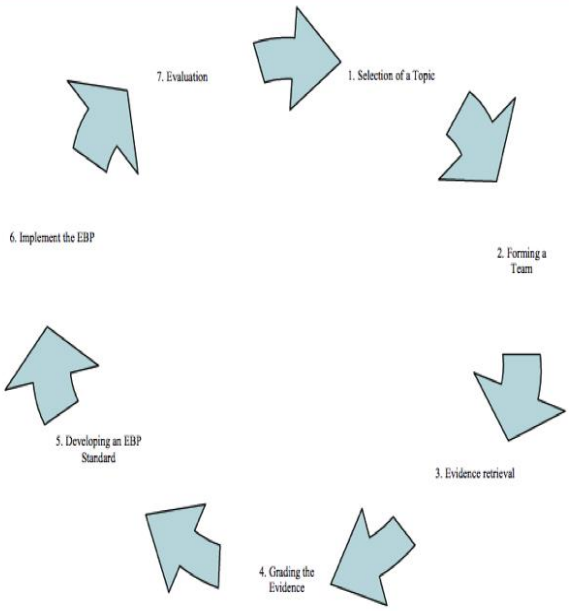
If Applicable:

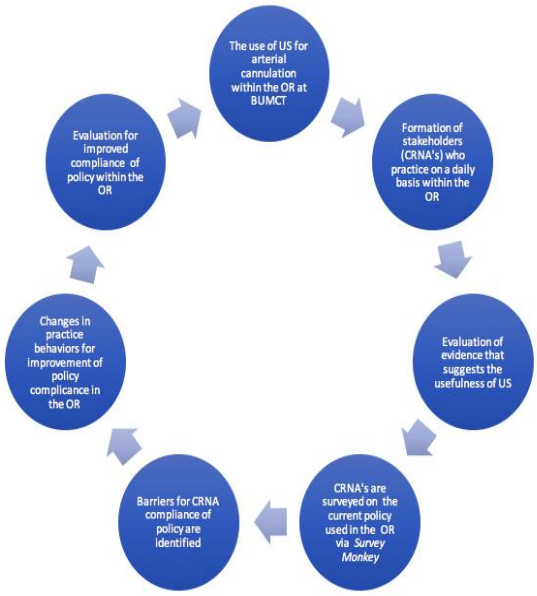
Medical Director:_____Date:_____Manager:_____Date_____

Unit or Service Based Educator:_____Date_____

APPENDIX B:

SEVEN STEPS OF THE IOWA MODEL - ADAPTATION



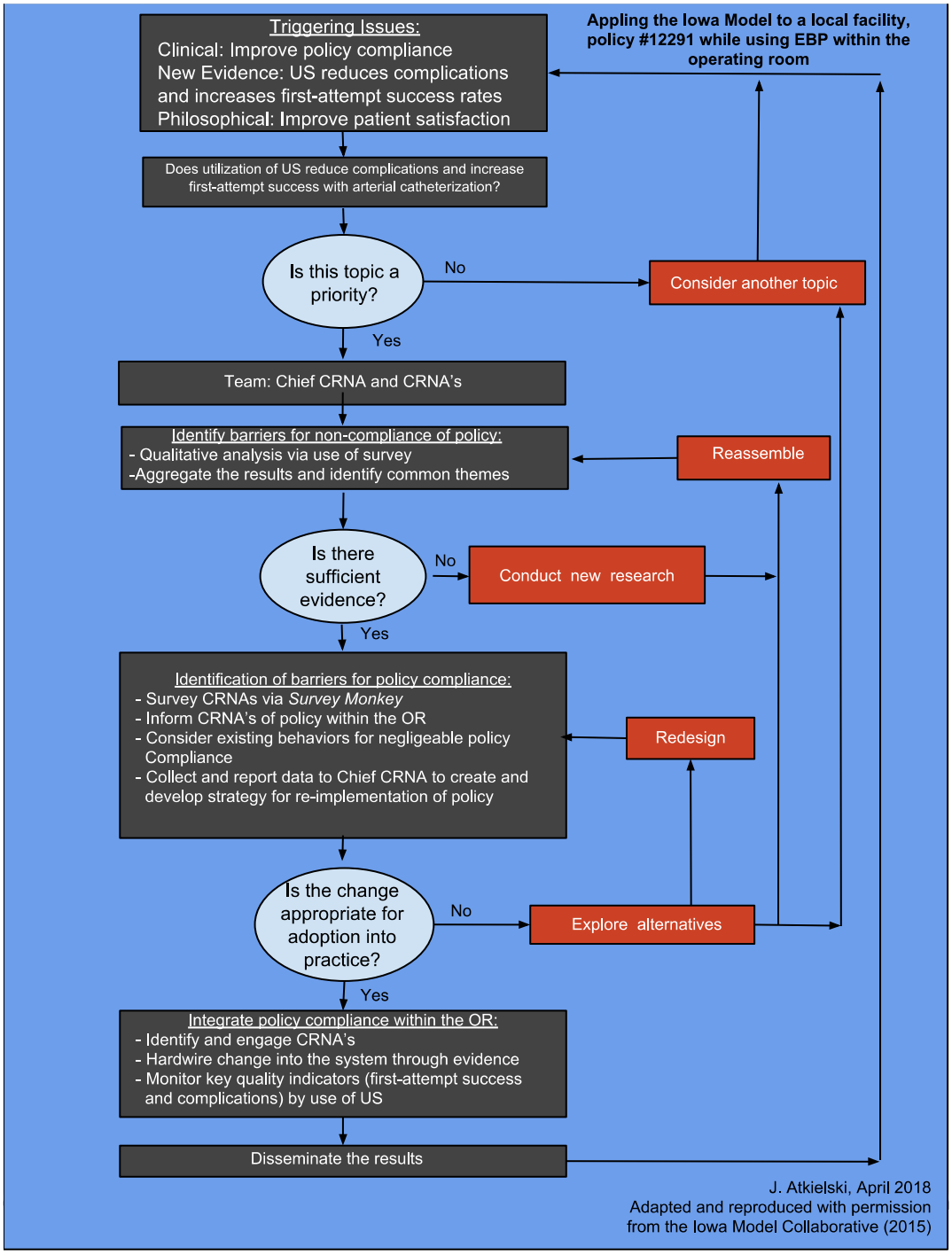


Seven steps of the IOWA model – Integrated to project plan

Used/reprinted with permission from Dr. Owen Doody from the University of Limerick (2019). Introducing evidence into nursing practice: Using the IOWA model. *British Journal of Nursing,* 1-10. DOI: 10.12968/bjon.2011.20.11.661

APPENDIX C:

APPLICATION OF THE IOWA MODEL


Appling the Iowa Model to a local facility, policy #12291 while using EBP within the operating room
Triggering Issues:
Clinical: Improve policy compliance
New Evidence: US reduces complications and increases first-attempt success rates
Philosophical: Improve patient satisfaction
Does utilization of US reduce complications and increase first-attempt success with arterial catheterization?
Is this topic a priority?
No
Consider another topic
Yes
Team: Chief CRNA and CRNA's
Identify barriers for non-compliance of policy:
- Qualitative analysis via use of survey
-Aggregate the results and identify common themes
Reassemble
Is there sufficient evidence?
No
Conduct new research
Yes
Identification of barriers for policy compliance:
- Survey CRNAs via Survey Monkey
- Inform CRNA's of policy within the OR
- Consider existing behaviors for negligeable policy Compliance
- Collect and report data to Chief CRNA to create and develop strategy for re-implementation of policy
Redesign
Is the change appropriate for adoption into practice?
No
Explore alternatives
Yes
Integrate policy compliance within the OR:
- Identify and engage CRNA's
- Hardwire change into the system through evidence
- Monitor key quality indicators (first-attempt success and complications) by use of US
Disseminate the results
J. Atkielski, April 2018
Adapted and reproduced with permission from the Iowa Model Collaborative (2015)

APPENDIX D:

LITERATURE REVIEW OF ULTRASONOGRAPHY AND ARTERIAL CATHERIZATION

Author / Article	Qual: Concepts or phenomena Quan: Key Variables Hypothesis Research Question	Theoretical Framework	Design	Sample (N)	Data Collection (Instruments/Tools)	Findings
Abdalla, U., Elmaadawey, A., & Kandeel, A. (2017). Oblique approach for ultrasound-guided radial artery catheterization vs transverse and longitudinal approaches, a randomized trial.	Quantitative. Assess the value using new techniques for ultrasound-guided radial artery catheterization; oblique approach; vs transverse and longitudinal views. Aims to combine benefits and avoid aforementioned approaches.	N/A	RCT non-blinded study	n= 126 surgical patients	G power software was used for sample calculation. Data was collected using IBM SPSS statistics. A one-way analysis of variance with Tukey post hoc analysis or the Kruskal-Wallis H test.	The oblique approach for ultrasound guided radial artery catheterization may replace the two classic approaches as it is superior success rate, higher first attempt success and shorter time consumed for catheterization.
Aouad-Maroun, M., Raphael, C., Sayyid, S., & Farah, F. (2016). Ultrasound-guided arterial cannulation for paediatrics.	Quantitative. To assess first attempt success rates and complication rates when ultrasound guidance is used for arterial line placement in the pediatric population comparing to traditional palpation and Doppler techniques.	N/A	Meta-Analysis	n=444 pediatric participants	5 RCT reporting arterial cannulations, four of which compared ultrasound with palpation, and one compared ultrasound with Doppler auditory assistance.	Ultrasound guidance produces superior success rates at first attempt (risk ratio 1.96, 95% CI 1.34 to 2.85, 404 catheters) and fewer complications, such as hematoma (RR 0.20, 95% CI 0.07 to 0.60, 222 catheters). Improved success rates within two attempts (RR1.78, 95% CI 1.25 to 2.51, 134 catheters) with ultrasound

Author / Article	Qual: Concepts or phenomena Quan: Key Variables Hypothesis Research Question	Theoretical Framework	Design	Sample (N)	Data Collection (Instruments/Tools)	Findings
						guidance compared to other types of guidance. Moderate-quality evidence suggests that ultrasound guidance for radial artery cannulation improves first and second attempt success rates and decreases the rate of complications compared with palpation and Doppler.
Kiberenge, R., Kenichi, U., & Rosauer, B. (2018). Ultrasound-gudied dynamic needle tip positioning technique versus palpation technique for radial arterial cannulation in adult surgical patients: A randomized controlled trial.	Quantitative. The "modified" ultrasound technique for vascular cannulation success, was assessed compared to palpation technique for radial artery cannulation in adult surgical patients.	N/A	Parallel RCT	n= 260	The operators included anesthesia residents, fellows, and faculty. Required to have placed at least 10 radial artery catheters using each technique prior to participation in the study. The data that was collected included first-pass success of radial arterial line placement, number of catheters used, number of skin perforations,	The first-pass success rate was 83% in the dynamic needle tip positioning technique group, and 48% in the palpation group (P<.001); RR 2.5; 95% CI, 1.7-3.6. Overall 5-minute success rate was 89% in the dynamic needle tip positioning

Author / Article	Qual: Concepts or phenomena Quan: Key Variables Hypothesis Research Question	Theoretical Framework	Design	Sample (N)	Data Collection (Instruments/Tools)	Findings
					time to achieve successful cannulation, systolic blood pressure before and after puncture, diastolic blood pressure before and after puncture, and heart rate before and after. The technique on first pass, overall success rate, and number attempts performed using X2 test or Fisher exact test. The Two-sample independent *t* test or Mann-Whitney *U* test was used to assess the effect of cannulation method on cannulation time.	technique compared to 65% in the palpation group (P<.001); RR was 2.4; 95% CI, 1.2-1.6. The number of skin puncture attempts was significantly more in the palpation group (P<.001). The use of the ultrasound-guided dynamic needle tip positioning technique increased first and overall success rates compared to palpation.
Marquis-Gravel, G., Tremblay-Gravel, M., Levesque, J., Genereux, P., Schampaert, E., Palisaitis, D., . . . Tessier, P. (2017). Utlrasound guidance versus anatomical landmark approach	Quantitative. To assess the effect of ultrasound guidance compared to anatomical landmark approach in patients requiring femoral artery access for coronary angiography.	N/A	RCT and Meta-Analysis (MA)	RCT: n= 129 patients (64 US-guided; 65 anatomical landmark). MA: n=1553 patients	Seven experienced interventional cardiologists were participating in cannulation and were all familiar with the use of ultrasound. Comparison using Pearson's X-square test or Mann-Whitney	After pooling aggregating the data, bleeding events, multiple puncture attempts, and venipunctures were significantly decreased with ultrasound guidance, but

Author / Article	Qual: Concepts or phenomena Quan: Key Variables Hypothesis Research Question	Theoretical Framework	Design	Sample (N)	Data Collection (Instruments/Tools)	Findings
for femoral artery access in coronary angiography: A randomized controlled trial and a meta-analysis.					U test. Primary and secondary endpoints were assessed using univariate logistic regression on an intention-to-treat basis.	successful common femoral artery cannulation was not improved (OR = 0.84; 95%CI: 0.060-1.17; P = 0.29).
Seto, A., Roberts, J., Abu-Fadel, M., Czak, S., Latif, F., Jain, S., . . . Lasic, Z. (2015). Real-time ultrasound, guidance facilities transradial access: RAUST (radial artery access with ultrasound trial).	Quantitative. To assess the utility of ultrasound guidance for transradial arterial access.	N/A	Multicenter RCT	n= 698 patients Ultrasound n=347 Palpation n=351	The Kolmogrorov-Smirnov and Shapiro-Wilk tests of normality were used to examine the distribution of data from continuous variables. The unpaired Student's *t*-test or Mann-Whitney *U* test was used for continuous variables. The Chi-squared or Fisher's exact test were used for proportions. Statistical analyses were performed using the SPSS statistical software program.	The number of attempts was reduced with ultrasound guidance (mean: 1.65 ± 1.2 vs 3.05 ± 3.4, P <0.0001). First-pass success rate improved (64.8% vs 43.9%, P <0.0001). The time was reduced (88 ± 78 seconds vs 108 ± 112, P = 0.006). Ten patients in the control group required crossover to ultrasound guidance after 5 minutes of failed palpation attempts with 8 of 10 (80%) having successful sheath insertion with ultrasound.

Author / Article	Qual: Concepts or phenomena Quan: Key Variables Hypothesis Research Question	Theoretical Framework	Design	Sample (N)	Data Collection (Instruments/Tools)	Findings
Shiloh, A., Savel, R., & Paulin, L. E. (2011). Ultrasound-guided catheterization of the radial artery.	Quantitative. To determine the utility of real-time two-dimensional ultrasound guidance for radial artery catheterization.	N/A	Systematic Review and Meta-analysis	n= 311 Palpation = 152 Ultrasound=159	Methodology was appraised by the Jaded criteria. The combined data was aggregated via RevMan software. A random effects model was used to estimate the relative risk of dichotomous outcomes. The X2 test was used to observe differences in results were compatible with chance alone. The I2 statistic was used to describe the percentage of the variability in effect.	Ultrasound guidance for arterial catheterization was associated with a 71% improvement for first-attempt success (RR, 1.71; 95% CI, 1.25-2.32). Ultrasound guidance for radial artery catheterization improved first-pass success rate.
Ueda, K., Bayman, E., Johnson, C., Odum, N., & Lee, J. (2015). A randomised conrtolled trial of radial artery cannulation guided by doppler vs palpation vs ultrasound.	Quantitative. Comparing three different radial arterial cannulation techniques (Doppler, palpation, and ultrasound).	N/A	RCT	n= 749 participants Doppler = 244 Palpation = 256 Ultrasound = 249	Anesthesia students 1-4 years performed the procedure in adult surgical patients. Personnel not involved in the participants' care recorded the number of skin punctures. Fisher's exact test was used to compare cannulation at first attempt and separately at 5 min.	Ultrasound increased the rate of cannulation at the first attempt by 14% (95% CI 5-22%), from 39% with Doppler or palpation, P = 0.002 for both. There were no differences in the rates of cannulation 5 minutes after the

Author / Article	Qual: Concepts or phenomena Quan: Key Variables Hypothesis Research Question	Theoretical Framework	Design	Sample (N)	Data Collection (Instruments/Tools)	Findings
					Normal continuous data distribution was assessed with the Shapiro-Wilks test while also using the ANOVA and independent t-test. The Kruskal-Wallis test or the Mann-Whiney U-test was used for continuous data collecting.	procedure started (all students had used ultrasound <5 times for radial cannulation).
Wan-Jie, G., Xiang-Dong, W., Fei, W., Zheng-Liang, M., & Xiao-Ping, G. (2016). Ultrasound guidance facilitates radial artery catheterization: a meta-analysis with trial sequential analysis of randomized controlled trials.	Quantitative. To evaluate the benefits and risks associated with ultrasound guidance compared with traditional palpation for radial artery catheterization.	N/A	Meta-analysis	Ultrasound guidance n=1,992 Doppler ultrasound guidance n=666 Palpation	Two authors independently evaluated the quality of evidence for primary and secondary outcomes according to the GRADE, (assessing for risk of bias, inconsistency, indirectness, imprecision, and publication bias. The I2 statistic was used to quantify for heterogeneity. A post hoc subgroup analysis is performed to check the influence of factors. All	The use of dynamic 2-D ultrasound guidance for radial artery catheterization decreases first-attempt failure, mean attempts to success, mean time to success, and the occurrence of hematoma complications. Ultrasound guidance is recommended as an adjunct to aid radial arterial catheterization.

Author / Article	Qual: Concepts or phenomena Quan: Key Variables Hypothesis Research Question	Theoretical Framework	Design	Sample (N)	Data Collection (Instruments/Tools)	Findings
					statistical analysis was performed using Stata 12.0. TSA is used to determine whether the evidence in a meta-analysis is reliable and conclusive.	
Yan-Bing, G., Jun-Hong, Y., Fu-Quan, G., Lei, P., Xiao-Zhi, W., & Chang-Jun, L. (2015). Effects of ultrasound-guidedradial artery catheterization: an updated meta-analysis.	Quantitative. Show that ultrasound guidance is an effective technique for radial artery catheterization.	N/A	Meta-analysis based on RCT's including non-English language studies	n= 803 patients	The RCT's were recorded by first author, year of publication, sample size, study population, and catheter specifications for each RCT used. Standardized Excel files were used to aggregate data. The Jaded scale was used to differentiate quality.	Ultrasound-guided radial artery catheterization was generally associated with a 47% improvement, as compared with the palpation technique, in terms of the rate of first-attempt success (RR, 1.47; 95%CI, 1.22-1.76; P<.0001). The ultrasound-guided technique significantly improved the rate of first-attempt success (RR, 1.39; 95% CI, 1.13-1.72; P = .002).

Author / Article	Qual: Concepts or phenomena Quan: Key Variables Hypothesis Research Question	Theoretical Framework	Design	Sample (N)	Data Collection (Instruments/Tools)	Findings
Zaremski, L., Quesada, R., Kovacs, M., Schernthaner, M., & Uthoff, H. (2013). Prospective comparison of palpation versus ultrasound-guided radial access for cardiac catheterization.	Quantitative. Comparing prospective data with ultrasound versus palpation-guided radial catheterization.	N/A	Prospective, single-center prospective trial.	n= 183 patient	Catheterization by an experienced cardiac interventionist. Comparison of data was made using a two-sided unpaired Student t-test, or non-parametric Mann-Whitney U-test or Chi-square test. The DuBois and DuBois equation was used to calculate the body surface area. Analyses were performed using SPSS software.	Operator experience may have correlation with successful cannulation. Therefore, ultrasound-guided radial access seems to provide no substantial additional benefit over palpation-guided access alone. In patients with absent pulse (due to obesity), ultrasound might confer some advantage over palpation.

APPENDIX E:

SURVEYED QUESTIONS USING SURVEY MONKEY

Policy for Arterial Cannulation

1. How many years of experience do you have as a CRNA?

- ○ 0-5
- ○ 6-10
- ○ 11-15
- ○ 16-20
- ○ 21+

2. How many radial arterial lines do you place annually (approximately)?

0 100

3. Please select the cases that would receive an arterial catheter.

- ☐ Craniotomy
- ☐ Vascular
- ☐ Cardiovascular
- ☐ Transplant
- ☐ Spine
- ☐ Trauma
- ☐ ENT
- ☐ Morbid Obesity
- ☐ Ortho (Beach chair position)
- ☐ Thoracotomy

4. Are you aware of the facilities policy, *Radial & Brachial Arterial Catheter: Insertion, Maintenance, and Removal Pol #12291?*

- ○ Yes
- ○ No

5. Have you **viewed** *Placing Peripheral Arterial Catheters* Power Point Presentation available on the facilities Intranet?

- ○ Yes
- ○ No

6. Please provide reasoning why you have or have not viewed this policy.

7. Have you received training for the use of ultrasound? (If "yes," explain type of training)

- ○ No
- ○ Yes (explain type)

8. Do you practice routine utilization of ultrasound when performing arterial catheterization?

9. Briefly explain the reasoning why or why not you use ultrasound for arterial catheterization.

10. In the last month, how many arterial lines have you placed with ultrasound?

- ○ 0
- ○ 1-5
- ○ 6-10
- ○ 11-15
- ○ 16-20
- ○ 20+

APPENDIX F:

EMAIL CORRESPONDENCE FOR SURVEY

To:

Cc:

Subject:

From: Jal A Atkielski – jalatk@email.arizona.edu

Dear CRNA-

Good day. You may know that for my Doctoral Nurse Practitice project, I am exploring the use of ultrasound with arterial catheterization.
The purpose of this project is to identify barriers why CRNA's are not complying with Banner University Medical Center's policy for the utilization of ultrasound with arterial catheterization.

If you choose to take part in this project, you will be asked to complete a 10 question survey that will take approximately 3 minutes. An automated email from ***Survey Monkey*** will be sent to you with link and closes one week from the day you received it. There are no foreseeable risks associated with participating in this project and you will receive no immediate benefit from your participation. Survey responses are anonymous.

If you choose to participate in the project, participation is voluntary, refusal to participate will involve no penalty or loss of benefits to which you are otherwise entitled. In addition, participation/non-participation will also not affect your current or future employment status at Banner University Medical Center. You may withdraw at any time from the project. You may skip any question that you choose not to answer. By participating, you do not give up any personal legal rights you may have as a participant in this project.

For questions, concerns, or complaints about the project, you may call Jal Atkielski at 520-360-7250 or Kathleen Piotrowski DNP, CRNA, CHSE, and Clinical Associate Professor at 520-626-5889.

Thank you for your participation,

Jal Atkielski SRNA

APPENDIX G:

FLYER – USING ULTRASOUND WITH ARTERIAL CATHERIZATION

Policy Compliance is Best Practice

A survey on policy #12291 for CRNA's for the use of **Ultrasound** during arterial catheterization

February 18-22, 2019

*A DNP – Project brought to you by the Chief CRNA and SRNA at BUMC-T

- Policy #12291 states that ultrasound is to be used for arterial catheterization
- Systematic and Randomized Control Trials have found increased first-attempt success rates when using ultrasound with arterial catheterization
- With ultrasound, there are reduced incidence of vasospasm, hematoma, and risk for infection

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